PLASTICS PIPE INSTITUTE

A Division of The Society of The Plastics Industry, Inc.

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WEATHERABILITY OF THERMOPLASTIC PIPING

PPI

TECHNICAL REPORT

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Foreward

This Technical report has been prepared to provide producers, users, engineers, and others interested in plastic pipe with a short summary report in relatively simple language of the technical literature and experiences with thermoplastic piping materials exposed directly to weathering elements. It should be noted that the statements made apply only to present plastic piping compounds and not necessarily to all types, kinds, and grades of plastics.

While reasonable efforts have been made by the Plastics Pipe Institute, the members of its technical groups, and its technical staff to provide reliable information in this report, no warranty or guarantee can be assumed by them for the statements made. It is recognized that the information is not complete, particularly with respect to unusual or special conditions.

Although an extensive search was made to obtain as many pertinent technical publications on the subject matter as possible, it is recognized that some pertinent publications may not have been revealed.

This report will be revised and up-dated as found necessary. Suggestions from readers on ways to improve it are welcome and should be sent to the address on the cover marked for the attention of the Technical Director.

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March 15, 1973

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INTRODUCTION

Plastics are being used to an ever increasing extent in outdoor environments, particularly as materials of construction. The movement of polymeric materials into construction has increased the importance of determining their useful performance life under conditions of outdoor service. This need applies equally to plastic pipe.

Locale and season have remarkable effects on plastics. The expected performance in one locale cannot be presumed, based on performance in another locale, particularly if the seasons of exposure differ. Reliable results can be obtained for a specific locale by long-term exposure in that locale. The resistance can be evaluated by rigorous controlled laboratory studies (accelerated weathering) that give the same types of chemical and physical changes that occur on outdoor exposure. Such evaluations when properly made and interpreted give highly satisfactory indications of service life on continuous exposure to the weathering elements.

FACTORS INFLUENCING WEATHERING

Sunlight – The solar radiation that is absorbed by a material may result in actinic degradation and the formation of heat. The energy may be sufficient to cause the breakdown of the polymer or resin and changes in compounding ingredients. Materials that are to be exposed to radiation from sunlight for long periods should be made from polymers that are not significantly affected by such radiation and/or are properly stabilized.

Temperature – The daily range of temperature varies considerably both with season and location and can be quite large. Heat from solar radiation can raise the temperature of directly exposed materials as much as 60 F higher than ambient. Such extremes of temperature over an extended period can cause physical damage. In addition, it should be remembered that chemical action rates increase exponentially as the temperature increases.

Moisture – Rain and humidity are the two main contributors of moisture with humidity having the greater overall effect. In general, humidity contributes a moist continuum in constant contact with the material to produce hydrolysis, leaching, etc. Rain provides a washing and impacting action.

Wind – Wind acts as a carrier of impurities such as dust, gases and moisture which can contribute to weathering effects. Similarly, the absence of wind can allow the accumulation of air contaminants, as in smog areas, which could contribute significantly to the weathering of a material.

Gases – The nature and quantity of gases vary widely but, in industrial areas especially, gases are present which can result in chemical action on some materials.

Location – The geographical location is also a factor. Less effects are produced where there are less sunlight hours per year and where the radiation is less intense. For example, a specific period of exposure in Arizona is more detrimental than in New Hampshire.

EFFECTS OF GEOMETRY AND STRESS

In general, weatherability data should be applied to the same configuration of the material as that employed in the exposure test. Experimental and practical results show that doubling the thickness of high density polyethylene appreciably increases the expected service life of this material (4).

Stresses may greatly reduce the service life of plastic parts exposed to the weather by acceleration of chemical and physical changes (4) and (6). Unstressed control specimens of various polyethylene compounds required considerably longer to show signs of degradation from natural ultraviolet light than did specimens exposed in the form of bent strips that contained high stresses (15) and (22).

NATURAL WEATHERING

Most natural weathering studies are conducted in accordance with ASTM D 1435-69, "Recommended Practice for Outdoor Weathering of Plastics." The intensity of solar radiation, of course, varies widely with the geographical location and time of year. One year's exposure in Arizona, for example, does not give the same degree of aging as a year's exposure in Florida or New Jersey. A month's exposure in July or August at any location is not the same as a month's exposure during December or January. Even at one location the variation in solar radiation from year to year can be as great as the total radiation for a whole month. Therefore, even a year as a unit for timing exposure is rather variable and cannot be used for direct comparison of samples unless they were exposed during the same period.

However, data and case histories from severe locations enable designers to properly design for applications at less severe locations. Change in tensile properties, color change, brittle point and other significant properties are used as criteria.

ACCELERATED WEATHERING

A number of devices are used to simulate weathering. These employ carbon arcs, mercury sunlamps, xenon arcs, or a combined fluorescent sunlamp-black light. Three of these are covered by ASTM Recommended Practices (23), (24) and (25).

None of these tests can be absolutely correlated with outdoor exposure. The reasons for this lack or correlation are:

1. The extreme variations in outdoor environment.
2. The radiation spectrum does not exactly duplicate the solar spectrum.
3. Temperatures and temperature ranges differ from outdoor conditions.
4. Humidity difference.

However, in spite of this lack of correlation with outdoor exposure, accelerated testing is an extremely useful tool for comparing the relative aging resistance of materials and rapidly screening out materials which have poor resistance. The same criteria of change in properties and appearance, used to evaluate natural weathering, are used for accelerated tests.

DESIGN CONSIDERATIONS

The following statements on weathering and aging characteristics of plastic piping materials can be used for guidance on piping systems utilizing these materials. The weathering statements are appropriate for piping systems that have been designed to withstand the temperatures and other environments encountered in a specific application.

WEATHERING OF POLYETHYLENE PIPE

Unstabilized polyethylene pipe has a limited life outdoors, and most pipe sold today contains a stabilizer system. For normal, outdoor storage, stabilized non-black systems are satisfactory, but for prolonged outdoor use, polyethylene should be stablized with carbon black.

Incorporation of carbon black in polyethylene compounds greatly increases their weather resistance (12) and (13). The carbon black screens the PE from damaging ultraviolet radiation. The resistance to aging imparted by the

carbon black depends upon its type and particle size, concentration and degree of dispersion in the PE (16). A high concentration, such as 2 percent, of carbon black is particularly desirable.

Farbwerke Hoechst A. G. in Germany reported, "We have had installed at our works for over seven years in an open air test, tubes of polyethylene under working pressure. Until now no damage through weathering has been determined. For completeness we must mention here that the water in the tubes is frozen in winter." (17) These tubes (pipes) contained 2% carbon black of 470 millimicron mean particle diameter.

There are not many case histories on the long-term outdoor performance of polyethylene pipe. However, there is every technical reason to accept that the performance would approximate that of polyethylene used in cable sheathing. Bell Telephone Laboratories report successful performance of polyethylene sheathing involving many thousands of miles in outdoor use for over 20 years. Cable sheathing is exposed to the most severe outdoor environments and some of it is under high stresses caused by bending the cable around insulators, etc. The Bell Telephone Companies have had thousands of miles of PE cable sheathing in service for periods up to 20 years, without any problems due to weather (18). This cable sheathing contains carbon black and antioxidant as do PE pipe compounds.

WEATHERING OF PVC PIPE

Rigid PVC pipe has good weather resistance if the compound is made with suitable pigments and has been properly compounded. Pipe intended for long-term out-of-doors exposure should be specified as requiring such properties; pipe not designed for outdoor applications may change in appearance and may not deliver good performance when used under such conditions.

In the present state of echnology, the compounding ingredients that have resulted in satisfactory outdoor performance tend to make the pipe opaque. Accordingly, transparent and translucent pipe may not have satisfactory resistance to deterioration in outdoor environments.

An example of the weather stability of properly compounded PVC material is offered by the installation at the Cherry Plaza Hotel, Orlando, Florida. Lightweight, rigid PVC pipe was used in the air conditioning system. Some of the pipe is located on the hotel roof where it has been exposed to at least 20,000 hours of Florida sunshine with temperatures up to 150° F during a decade of service. The pipe has shown excellent resistance to weather deterioration and is continuing to deliver satisfactory performance.

Reiterating, PVC will perform well in outdoor applications if designed for those conditions. Pipe made from normal PVC compounds may not deliver equally satisfactory performance out-of-doors.

WEATHERING OF ABS PIPE

ABS pipe usually contains carbon black to give protection from sunlight. The effects of the ultraviolet radiation from the sun are substantially reduced in pipe so protected, and permit the use of ABS pipe in certain outdoor applications. The largest outdoor use is probably as vent pipes of DWV systems which are fully exposed to all weathers.

Prolonged exposure of such items has not affected their utility. Close examination has shown that only a very thin surface layer of the pipe has been affected by sunlight, even after several years exposure.

No adverse effects have been found from other weather conditions such as wet or cold, nor from the geographical location.

WEATHERING OF OTHER PIPE MATERIALS

No case histories for CAB (Cellulose Acetate Butyrate), and PP (Polypropylene) pipe installations involving prolonged exposure to weather were located. Data from artificial and natural weathering tests is contained in References (12) and (21). However, none of the materials appeared to be pipe compounds and some of them did not contain UV absorbers or antioxidants.

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PPI TECHNICAL REPORTS

Designation	*Title*
TR1-NOV 1968	A Glossary of Plastics Piping Terms
TR2-OCT 1968	Recommended Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe.
TR3-AUG 1973	Policies and Procedures on Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe
TR4-MAR 1972	Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Pipe Compounds
TR5-AUG 1973	List of Standards for Plastic Piping
TR6-FEB 1968	Recommended Standard Terminology For Dimensions of Plastic Pipe Fittings. Copies no longer available, see ASTM D 2749
TR7-MAR 1968	Recommended Method for Calculation of Nominal Weight of Plastic Pipe
TR8-APR 1968	Polyethylene Piping Installation Procedures
TR9-OCT 1968	Recommended Standard Service (Design) Factors for Pressure Applications of Thermoplastic Pipe Materials
TR10-FEB 1969	Recommended Practice for Making Solvent-Cemented Joints with PVC Pipe and Fittings
TR11-FEB 1969	Resistance of Thermoplastic Piping Materials to Micro- and Macro-Biological Attack
TR12-SEPT 1969	Acrylonitrile-Butadiene-Styrene Plastic (ABS) Piping Installation Procedures
TR13-MAR 1971	Polyvinyl Chloride (PVC) Plastic Piping Design and Installation
TR14-MAR 1971	Water Flow Characteristics of Thermoplastic Pipe
TR15-AUG 1973	Recommended Practice for Bending Polyvinyl Chloride (PVC) Conduit in the field.
TR16-AUG 1973	Thermoplastic Water Piping Systems
TR17-AUG 1972	Thermoplastic Piping for Swimming Pool Water Circulation Systems
TR18-MAR 1973	Weatherability of Thermoplastic Piping
TR19-AUG 1973	Thermoplastic Piping for the Transport of Chemicals
TR20-SEPT 1973	Joining Polyolefin Pipe
TR21-SEPT 1973	Thermal Expansion and Contraction of Plastic Pipe
TR22-JULY 1974	Polyethylene Plastic Piping Distribution Systems for Components of Liquid Petroleum Gases

PPI TECHNICAL NOTES

Designation	*Title*
TN1-MAR 1970	Sealants for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Piping
TN2-MAR 1970	Sealants for Polyvinyl Chloride (PVC) Plastic Piping
TN3-MAY 1971	Electrical Grounding
TN4-AUG 1971	Odorants in Gas Pipelines

TN5-JAN 1972	Testing Equipment
TN6-MAR 1972	Coiling Polyethylene Plastic Pipe and Tubing
TN7-SEPT 1973	The Nature of Hydrostatic Time-to-Rupture Plots
TN8-AUG 1973	Making Threaded Joints with Thermoplastic Pipe
TN9-AUG 1973	Coiling PVC Plastic Pipe and Tubing

PPI RECOMMENDATIONS AND STATEMENTS

A. Limiting Water Velocities in Thermoplastic Piping Systems, January 5, 1971

B. Thermoplastic Piping for the Transport of Compressed Air and Other Compressed Gases, January 19, 1972

C. Pressure Rating of PVC Plastic Piping for Water at Elevated Temperatures, August 1, 1973

D. Polyethylene Plastic Pipe System for Commercial Propane Gas Distribution, October 5, 1973

E. Criteria for Joining Various Polyethylene Materials to One Another by Heat Fusion Techniques, April 3, 1974

PPI PRODUCT DIRECTORY

1973-74 Plastics Pipe Institute Member Company Product Directory, Issued 1973